DECEMBER, 1916 BULLETIN 213

VIRGINIA POLYTECHNIC INSTITUTE

VIRGINIA AGRICULTURAL EXPERIMENT STATION

GREATER BALTIMORE TOMATO, ONE OF THE VARIETIES USED IN THE EXPERIMENTS. (One-half natural size)

Spraying and Dusting Tomatoes

BY

F. D. FROMME and H. E. THOMAS

BLACKSBURG, MONTGOMERY COUNTY, VIRGINIA

ORGANIZATION

OF THE

VIRGINIA AGRICULTURAL EXPERIMENT STATION

BOARD OF CONTROL

The Executive Committee of the Board of Visitors of the Virginia Polytechnic Institute.

JOHN THOMPSON BROWN, Chairman	R. F. D., Evington, Bedford County
J. B. WATKINS	Midlothian, Chesterfield County
J. A. TURNER	Hollins, Roanoke County
W. C. SHACKLEFORD	Proffit, Albemarle County
J. D. EGGLESTON, ex officio	Blacksburg, Montgomery County

STATION STAFF

J. D. EGGLESTON, A. M	President
A. W. DRINKARD, JR., Ph. D	Director
H. L. PRICE, M. S	Horticulturist
W. B. ELLETT, Ph. D	Chemist
W. J. SCHŒNE, M. S	Entomologist
T. B. HUTCHESON, M. S	Agronomist
F. D. FROMME, Ph. D	Plant Pathologist and Bacteriologist
R. E. HUNT, M. S	Associate Animal Husbandman
C. W. HOLDAWAY, M. S	Associate Dairy Husbandman
E. R. HODGSON, M. S	Associate Agronomist
H. H. HILL, M. S	Associate Chemist
G. C. STARCHER, B. Agr	Associate Horticulturist
T. J. MURRAY, M. S	Associate Bacteriologist
K. E. QUANTZ, M. S	Special Asst. in Horticulture
T. K. WOLFE, M. S	Assistant Agronomist
M. T. SMULYAN, Ph. D	Assistant Entomologist
H. E. THOMAS, M. S	Assistant Plant Pathologist
A. A. INGHAM, B. S	Assistant Horticulturist
C. I. WADE	Treasurer
J. B. FOGLEMAN	Executive Clerk

COUNTY EXPERIMENT STATIONS

E. R. HODGSON, M. S	Supervisor County Experiment Stations
W. W. GREEN (Bowling Green)	Supervisor Tobacco Investigations, and Superintendent Bowling Green, and Louisa Station
B. G. ANDERSON, B. S. (Appomattox)	Superintendent Appomattox Station
R. P. COCKE (Williamsburg)	Superintendent Williamsburg Station
*J. M. TRIMBLE, M. S. (Staunton)	Superintendent Staunton Station
J. C. HART, B. S. (Chatham)	Superintendent Chatham Station
*A. N. HODGSON, M. S. (Martinsville)	Superintendent Martinsville Station
*R. H. COOK, B. S. (Charlotte C. H.)	Superintendent Charlotte Station
E. T. BATTEN, B. S. (Holland)	Superintendent Holland Station

*In coöperation with the State Board of Agriculture.

Bulletins and reports are mailed free to all residents of the State who apply for them.

SPRAYING AND DUSTING TOMATOES[1]

By F. D. Fromme and H. E. Thomas

When advised to spray tomatoes for the prevention of "blight" and "rots" the questions invariably asked by the grower are: "Will it pay? Will the gain from spraying offset the cost, labor and inconvenience?" Many have stated that the slight margin of profit in tomato growing would not permit of any additional expense. The experiments reported herein were designed to provide an answer to some of these questions and to determine the comparative value of certain spray materials. While the experiments cover only a single season, 1916, they are in substantial agreement with those previously reported from this station,[2] and may be considered a fair statement of the results to be expected in those sections having climatic conditions similar to those at Blacksburg, and subject to attacks of late-blight and rot.

Plan of the Experiments

The experiments provided for a comparative study of the efficiency of different spray materials and especially of some fungicides applied in the dry (dust) form for the control of tomato diseases. Dust applications have been used in an experimental way with success against certain plant diseases, particularly some of those found on orchard trees and bush fruits, but the practical value of the method has not yet been established. The chief advantages claimed for the dusting method are: greater rapidity and ease of application, greater penetration through dense foliage, freedom from spray injury, and the possibility of dusting during weather unsuited for spraying. The advantages of the light outfits employed in dusting which can be transported readily over steep, rough ground remote from an adequate water supply, would be especially applicable for tomato work. A finely ground sulphur has been the chief fungicide used in recent experimental dusting work.

Details of the Experiments

Six plats, each consisting of a single row of 40 plants covering 640 square feet, or approximately one-seventieth of an acre, were provided.

[1]Paper No. 46 from the Laboratories of Plant Pathology and Bacteriology. Va. Agr. Exp. Sta.
[2]Reed, H. S., Tomato blight and rot in Virginia. Virginia Agri. Exp. Station., Bul. 192, 1911.

The plats were located on the experimental grounds at Blacksburg on a silt loam soil that had not been used for tomatoes previously, or at least for a considerable period. Each plat contained 20 plants of Stone and 20 of Greater Baltimore. The materials used on each plat with dates of application are given in Table I.

TABLE I.—*Treatment Received by Plats*

PLAT NO.	MATERIAL USED	DATES OF APPLICATIONS				
1	Check	No spray treatment				
2	Bordeaux Mixture[1] 4-5-50			July 19	Aug. 5	Aug. 17
3	"Superfine" sulphur[2] and arsenate of lead	June 7	June 29	July 19	Aug. 5	Aug. 17
4	"Insecto"[3]		June 29	July 19	Aug. 5	Aug. 17
5	Bordeaux mixture 4-5-50	June 7	June 29	July 19	Aug. 5	Aug. 17
6	"Pyrox"[4]	June 7	June 29	July 19	Aug. 5	Aug. 17

The plants were grown from seed in the greenhouses of the Experiment Station. They were set in the field on May 22, on the check row system 4'x4' and allowed to trail on the ground without supports.

All plats received the same cultivation and other field treatment except the spray and dust applications. The soil was uniform throughout, although the Stone plants were on slightly higher ground than the Greater Baltimore.

The liquid applications were made with a four-gallon compressed-air hand sprayer, a three-foot extension rod and angle nozzle being used to facilitate covering of both lower and upper surfaces of the leaves. The dust applications were made with a "Corona" hand duster. No records of quantities of materials used are given. It is impracticable to calculate

[1]Prepared in the usual way from 4 pounds of copper sulphate (bluestone), 5 pounds of stone lime, and 50 gallons of water.

[2]The mixture contained 85 parts "Superfine" sulphur and 15 parts dry arsenate of lead. "Superfine" sulphur is made especially for dusting by the Union Sulphur Co., of New York, and is so finely ground that 95 percent passes through a screen having 200 meshes to the inch. The arsenate of lead was supplied by the Corona Chemical Co., of Milwaukee, and is sold under the trade name of "Corona Dry."

[3]"Insecto" is a dusting mixture prepared by the Sherwin-Williams Co., of Cleveland. According to their analysis the mixture contained arsenic, zinc oxide, zinc sulphate, lead, metallic zinc and metallic copper. The material was considered to be in the experimental stage and has not been placed on the market at this writing.

[4]The dilution used was 1 pound of Pyrox to 6 gallons of water, as recommended for low pressure spraying. The material was furnished by the Bowker Insecticide Co., of Baltimore.

the amounts needed for large areas from operations with small hand equipment. All parts of the plants were thoroughly covered at each application.

The plants used in plats 2, 3, 4 and 5 received a spray of Bordeaux, 2-3-50, one week before setting in the field. Plat 6 was given a Pyrox spray at the same time, and plat 1 had no spray and served as a check. No fungous diseases developed prior to setting in the field, nor for two months after setting. The value of the early spray in this instance was, therefore, in the insurance provided and not in control of fungous attack.

Injurious insects were not present on the plats until late in the season when the tomato fruit worm, *Heliothis obsoleta,* was found to a slight degree about equally on all plats. Owing to this freedom from insects no arsenicals were added to the Bordeaux.

The Leaf-spot Infection

The first disease to appear on the plants was leaf-spot[1] caused by the fungus, *Septoria lycopersica* Speg. This disease had been found on a neighboring field, where a variety test of tomatoes was conducted, almost seven weeks earlier, June 3. The part of this field where the leaf-spot first appeared had grown a crop of tomatoes the year preceding, whereas the spray plats, as mentioned, were on land that had probably never been used for tomatoes before. The plants used in these two fields had been grown in the same greenhouses and were set at the same time. The primary infections on the plants in the variety test were, without doubt, due to fungous material wintered over in the soil.

An interesting point in connection with the leaf-spot attack was the slow rate of progress across the variety test field to the spray plats. The variety test consisted of 58 rows of about 80 plants per row. Row 1 was on the side farthest from the spray plats and ran parallel with them. Row 58 was about 30 feet from the nearest row of the spray plats. The first 30 rows were on the land that had grown tomatoes in 1915. The leaf-spot

[1]The Septoria leaf-spot is the most common and widespread of all tomato diseases. General signs of this disease are an unthrifty condition of the plant, the yellowing and dropping of leaves beginning at the base of the plant, and the failure of fruit to ripen evenly or rapidly. A close examination of leaves shows them to be covered with a varying number of small spots (Fig. 1) from pin-head size to one-eighth of an inch, or sometimes more in diameter. The spots are blackish in color, becoming gray with age, and bear one or more small black bodies which contain the spores of the fungus. The leaf tissue around the spots becomes yellowish and in a few days the entire leaf and petiole yellows, droops, dries up and falls from the stems at a slight jar (Fig. 2). Stems also frequently bear these spots (Fig. 2), but the infection here is not serious. No fruit rot is produced. The lower leaves are first attacked, usually about the time of full bloom, although the disease may appear in the seed-bed or soon after transplating. The disease progresses upwards killing the leaves in turn. The plants may keep alive by producing new leaves at the tips, but in the case of a severe attack cannot properly mature or ripen fruit. Leaf-spot is usually more severe on plants allowed to trail than on staked plants.

infection of June 3, was confined to the first few rows of the variety test. A month later, July 6, the infection had spread to row 30, and on July 21 had appeared on the remaining rows of the variety test and on the spray plats. This slow rate of advance is in agreement with the belief that the spores of *Septoria* are not carried about by the wind, and that the infection is spread chiefly by the splashing of rain-drops or by handling or working the plants while wet.[1] Examinations which were made of the bodies and feces of insects found feeding on infected plants failed to reveal any spores of *Septoria.*

FIG. 1.—Leaf-spot in Early and Later Stages of Development on Tomato Leaves

The leaf-spot produced considerable injury on the plats in a comparatively short period. An estimate of the degree of infection on August 12, three weeks after its appearance, was made by counts of dead, infected and healthy leaves on two plants of each variety in each plat. The number

[1]Levin, Ezra. The leaf-spot disease of tomato. Michigan Agr. Exp. Sta. Tech. bul. 25: 40. 1916.

of count plants was too small to overcome individual variation and satisfactory comparisons of the results from treatment on the different plats could not be drawn. To the eye, however, the foliage of both sprayed plats showed greater freedom from leaf-spot than the unsprayed and this was substantiated by the counts. The plats receiving dust applications, on the other hand, showed little or no gain from treatment. A noteworthy feature of the counts was that the Stone plants in all plats invariably showed a higher percent of dead leaves and a lower percent of non-infected

FIG. 2.—TOMATO LEAVES, LEFT, SHOWING TYPICAL DEATH FROM LEAF-SPOT. TOMATO STEM, RIGHT, ATTACKED BY THE LEAF-SPOT FUNGUS.

leaves than the Greater Baltimore. The Stone plants showed a range between 29 and 45 percent dead leaves, and 28 and 43 percent non-infected, whereas, the Greater Baltimore showed a range between 15 and 39 percent dead leaves and 33 and 62 percent non-infected. The differences between the two varieties on the unsprayed plat were: Stone 40 percent dead, 28 percent non-infected; Greater Baltimore 31 percent dead, 49 percent non-infected. It seems probable that these differences are due to a variation in the susceptibility of the two varieties. Such an explanation is strongly suggested and is in agreement with studies of varietal susceptibility, as yet

unpublished, which indicate that Greater Baltimore is more resistent to leaf-spot than Stone. Apparently the mere selection of Greater Baltimore in preference to Stone would have given results equal to those obtained by spray or dust applications on Stone, since the greatest gain in non-infected leaves due to spraying, about 15 percent on plat 2, is less than the difference in percent of non-infected leaves between the two varieties.

The failure to secure satisfactory control of leaf-spot is in agreement with the experience of others. Norton[1] states that not more than 10 to 20 percent of increase is to be expected in Bordeaux spraying for this disease. The arrangement of plats in our experiment is considered faulty in that the overlapping of plants as they reached maturity produced conditions favorable for considerable cross infection between the plats.

The experiments as planned provided for a comparison between fruit yield and leaf-spot infection to obtain a more exact statement of the results from treatment. A severe attack of late-blight and fruit rot, however, made it impossible to obtain any record of fruit yield as determined by leaf-spot infection.

The Late-blight Infection

The late-blight[2] caused by the fungus *Phytophthora infestans* (Mont.) De Bary, was first noted on the spray plats on August 5, although it had probably been present a few days earlier. Here again the infection was transferred to the spray plats from the variety field. Infection appeared in this field on July 20 on a few plants of a single variety located near the center of the field in row 33. In striking contrast to the leaf-spot the late-blight infection had spread over the entire field within a week or ten days, producing a general epidemic in about one-seventh of the time required by the leaf-spot. The greater rapidity of spread is due to the facts that the

[1]Norton, J. B. S. Maryland Agr. Exp. Sta. Bul. 180: 102-114. 1914.

[2]The late-blight disease is most prevalent in Virginia in the counties lying to the south and west of Roanoke. Leaves, stems and fruits are attacked. The spots on the leaves are much larger than those produced by **Septoria** and have a characteristic water soaked appearance in the early stages followed by a curling and blackening that resembles frost injury. The entire leaflet or leaf may be involved. On the stems elongated sunken areas are produced, which soon girdle and destroy them. A white down is present on the lower surface of leaf-spots and on the surface of stems. In contrast with leaf-spot the late-blight may first attack leaves on any part of the plant and often attacks and kills the growing points. Although quite serious on leaves and stems, the disease is most destructive on fruits. Infection almost invariably takes place through the stem end and the entire fruit is soon involved and rotted. Green and ripening fruits of all sizes are attacked. Brownish discolorations on the green fruit around the point of attachment of the stem are indications of early stages of infection (Fig. 3) and are soon followed by a sunken and blackened condition (Fig. 3) and a wet rot due largely to the entrance of bacteria and secondary fungi. The entire crop of green and ripening fruit may be destroyed. This fungus produces the well known late-blight disease of potatoes and potato fields are often sources of infection for tomatoes.

spores of *Phytophthora* are carried by air and that the time necessary to complete the cycle, from infection to spore production, is normally about one-half that required by *Septoria*.

The estimates of leaf-spot infection on August 12 also included counts of sound and rotting fruit produced by late-blight. No entire leaves had been killed by late-blight at this time, although leaf infection was prevalent and many leaflets had died. In no case was late-blight found on leaves in an advanced stage of leaf-spot attack. One could easily distinguish between the leaf injury produced by the two diseases, but a statistical expression of the degree of infection from late-blight was impracticable.

The fruit rot present was almost entirely due to late-blight. Stem-end infections were the rule, although entrance was sometimes effected through wounds or cracks. Counts made of all infected and sound fruits on two plants of each variety in each plat gave a fair estimate of the percent of fruit rot at this time, and an indication of the effectiveness of the applications. (See table 2.)

TABLE 2.—*Late-blight Infection of Tomato Fruits on August 12*

VARIETY	STONE						GREATER BALTIMORE					
Plat No.	1	2	3	4	5	6	1	2	3	4	5	6
Infected	12	3	4	1	4	5	42	13	32	39	23	26
Sound	44	46	38	76	41	58	47	50	107	72	106	61
Percent infected	21	6	9	1	8	8	47	21	23	35	18	30
Percent sound	79	94	91	99	92	92	53	79	77	65	82	70
Percent gain		15	12	20	13	13		26	24	12	29	17

The check plat of Greater Baltimore shows the highest percent of infection with approximately one-half of the fruits diseased. It is noticeable that all plats of Greater Baltimore show more infection than the corresponding plats of Stone. This is probably due to the lower ground and heavier foliage of the variety, both of which hindered drying. All plats receiving treatment show gains over the check, the two Bordeaux plats, Nos. 2 and 5 in each variety, maintaining a distinctly high relative efficiency. Here again the number of count plants was too small to give an accurate expression, but with few exceptions the degree of control shown is substantiated in the fruit yields for the season.

Fruit Yields as Affected by Fungicidal Applications

Although fruit rot continued throughout the remainder of the season, it was checked considerably by a period of dry weather during the last three or four weeks. All sound, ripe fruit was harvested and weighed. The first picking of any importance was made on August 17, although small quantities had been harvested at intervals from July 14. The harvest continued until a frost on September 19. Fruit weighings were made in grams and are expressed in pounds and bushels for greater convenience. Table 3 is a summary of total yields on all plats.

All plats receiving treatment show substantial gains over the check in fruit yield. The percent of gain on the Greater Baltimore plants, ranging from 141.6 to 306.2 percent, is considerably higher than on the Stone, 84.6 to 136.7 percent, due to the greater severity of the infection on the check plat of Greater Baltimore.

A noteworthy feature of the table is the high standing of plat 4, dusted with Insecto. This plat stands first in point of yield on the Stone and second on Greater Baltimore, and compares very favorably with the liquid applications. Although the Insecto plat received fewer applications than some of the sprayed plats, it is probable that applications made prior to July 19 had little or no effect on the late-blight and direct comparisons between the dusted and sprayed plats may be made. No advantage was taken of the possibility of dusting during weather when it was impossible to spray. It seems probable that the dust mixture might have been more effective if more frequent application had been made during the critical rainy period of the last two weeks of July and the first two of August. One case where spraying with Bordeaux and Pyrox failed to control late-blight during the same season was noted, the failure being due to the impossibility of applying a spray during two weeks of almost incessant rainfall.

Plat 5, Greater Baltimore, which had five applications of Bordeaux, produced the highest individual yield, 158 pounds, and percent gain over the check, 306.2 percent. Estimated on the acre basis, the production was 358 bushels, a gain of 270 bushels over the check and a gross money gain of $82.06. The cost of spraying on the acre basis cannot be determined accurately from the cost of small plat work. The total cost of five applications of Bordeaux on potatoes is usually given at about $5.00. This figure would probably be doubled for tomato spraying with Bordeaux, assuming normal prices of copper sulphate, as more material is needed and hand spraying is preferable to row spraying with a machine.

Sulphur in the dust form was the least effective of the materials used, although even here substantial gains over the check were realized.

TABLE 3.—*Total Yields of Sound, Ripe Fruit from Tomato Plats*

	Variety	Stone						Greater Baltimore					
	Plat No.	1	2	3	4	5	6	1	2	3	4	5	6
Yield per plat	Pounds	50.7	93.6	93.8	120.0	113.9	115.7	38.9	126.8	94.0	131.5	158.0	119.7
	Gain, pounds		42.9	43.1	69.3	63.2	65.0		87.9	55.1	92.6	119.1	80.8
	Gain, percent		84.6	85.0	136.7	124.7	128.2		226.0	141.6	238.0	306.2	207.7
Yield per acre calculated	Pounds	6,901.5	12,741.3	12,768.5	16,335.0	15,504.6	15,749.6	5,295.2	17,260.6	12,795.7	17,900.4	21,507.7	16,294.1
	Bushels[1]	115.02	212.36	212.80	272.25	258.41	262.49	88.25	287.81	213.26	298.34	358.46	271.57
	Gain, bushels		97.34	97.78	157.23	143.39	147.47		199.56	125.01	210.09	270.21	183.32
	Value[2]	$34.50	$63.70	$63.84	$81.67	$77.52	$78.74	$25.47	$86.34	$63.97	$89.50	$107.53	$81.47
	Gain		$29.20	$29.34	$47.17	$43.02	$44.24		$60.87	$38.50	$64.03	$82.06	$56.00

[1]The weight of a bushel of tomatoes is figured at 60 pounds.

[2]All tomatoes were sold locally at 75¢ per bushel, but the value is calculated at 30¢ per bushel, the price commonly paid by the canneries for a 60-pound bushel during the season.

Experiments at Other Places

During the same season spraying experiments were conducted at Roanoke in coöperation with Mr. J. S. Showalter, and at Buchanan in coöperation with Mr. H. A. Latane. Three plats were provided at each place, one receiving Bordeaux, one Pyrox and the other serving as a check.

The plats at Roanoke were a complete failure owing to an attack of the *Fusarium* wilt. More than 80 percent of the plants had succumbed to this disease by the middle of August, and the experiment was abandoned. It is well known that spraying is not effective against this disease.

The plats at Buchanan were sprayed on June 17, July 8, and July 25. Leaf-spot *(Septoria)* was the only foliage disease present of any importance, but a fruit-rot promoted by a prolonged period of rainy weather was

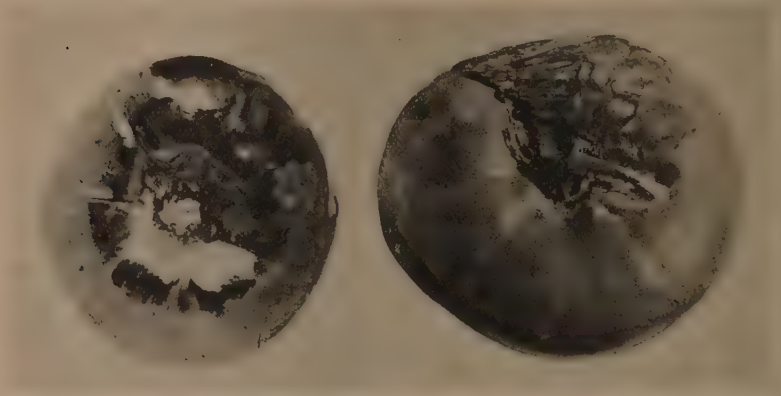

FIG. 3.—Rot of Tomato Fruits Produced by Late-blight Fungus. Left, Early Stage of Rot at Stem End. Right, Later Stage and Wet Rot Condition.

prevalent and very destructive on fruits lying in contact with the soil. An estimate of the leaf-spot infection on August 3, gave the following percents of non-infected leaves: Check 25.6 percent, Bordeaux 31.1 percent, Pyrox 32.0 percent. To the eye there was practically no difference between the plats. Earlier and more frequent applications might have given better control.

The leaf-spot disease was prevalent throughout Roanoke and Botetourt counties during 1916. No fields examined were found free from it. A field of about 15 acres at Troutville showed by count, on August 4, 39 percent dead leaves and 42 percent non-infected. This disease is widely distributed throughout the state, having been recorded from all sections, and is probably the chief fungous pest of the tomato in the canning districts.

RECOMMENDATIONS FOR THE CONTROL OF TOMATO DISEASES

Seed Bed Treatment.—Use new soil when possible. To prevent damping-off treat the soil before planting with formalin 1 part, water 100 parts, using two quarts of the solution to each square foot of soil. Work the soil fine before treating and cover with cloth or paper to retain fumes for about two days, then uncover and allow fumes to escape for a week before planting seed.

One or more sprays of Bordeaux mixture will provide protection in the seed bed, and for a short time after transplanting.

Field Treatment.—Do not grow tomatoes on the same field two years in succession. A rotation of three or four years is advisable.

Spray with Bordeaux mixture or proprietary compounds of known value as many times as needed according to weather conditions.

The first field spray may be applied about the time of first blooming and should be repeated every ten days or two weeks, or longer in dry weather. Apply the spray to both sides of the leaf and cover all parts of the plants.

Spraying is especially recommended for those sections subject to attacks of late-blight and rot.

If insects are troublesome add 3 or 4 pounds of arsenate of lead paste to each 50 gallons of Bordeaux or remove them by hand.

Avoid unnecessary handling of the plants or cultivating while wet.

SUMMARY

The application of fungicides in both liquid and dry forms did not give satisfactory control of the *Septoria* leaf-spot. Two applications of Bordeaux mixture prior to August 12, produced a gain in non-infected leaves of 15 percent as shown by counts at this time. This was the greatest gain realized from spraying or dusting for leaf-spot control.

The difference in the percent of leaf-spot infection on the two varieties used in the experiments was greater than that obtained by spraying. The Greater Baltimore plants in the unsprayed plat showed 49 percent non-infected leaves as compared with 28 percent on the Stone, a difference of 21 percent in favor of Greater Baltimore. This difference is apparently due to the higher resistance of Greater Baltimore to leaf-spot infection.

Late-blight and fruit rot *(Phytophthora)* were effectively checked and controlled with both liquid and dust applications. A gain of 306 percent

and a calculated increase of 270 bushels per acre over the unsprayed plat were obtained on the plants of Greater Baltimore in the plat which was sprayed five times with Bordeaux mixture.

The plat dusted with " Insecto," an experimental dusting mixture containing copper, gave a yield second only to Bordeaux on one variety and slightly exceeding it on the other.

The fruit yield on the Pyrox plat slightly exceeded that of the corresponding Bordeaux plat on one variety and fell considerably below it on the other.

Sulphur applied in the dry form ("Superfine") was the least effective of all materials used.

No foliage or fruit injury was produced by any of the spray or dust applications.

The importance of rotation in the control of leaf-spot is shown in the early freedom from this disease of plants grown in soil that had not been used previously for tomatoes.